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PAPERS ON INSECTS AFFECTING VEGETABLES.

THE SUGAR-BEET WEBWORM.

BY

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A REPORT OF PROGRESS REGARDING THE SUGAR-BEET WEBWORM.

(*Loxostege sticticalis* L.)

By H. O. Marsh,
Entomological Assistant.

INTRODUCTION.

During portions of the years 1909 and 1910 and nearly all of 1911 the writer, stationed in the Arkansas Valley of Colorado and Kansas, was engaged in a study of the insects affecting sugar beets and truck crops. Among the foremost of the species of insects studied was the sugar-beet webworm (*Loxostege sticticalis* L.). Although the investigation of this pest has not been completed, control measures have been fairly definitely worked out, and this preliminary article is presented with the hope that it will stimulate greater interest in the subject among the beet growers, and thus render the completion of the study more easily accomplished.

Sugar beets have been produced on a commercial scale in the Arkansas Valley since 1900, and almost from the beginning this crop has been infested by webworms. The injury produced by these infestations has varied greatly from year to year. During some seasons little noticeable damage has occurred, while on a few occasions the infested acreage has been extensive and the losses serious. As an example it may be mentioned that in 1910 practically 4,000 acres of beets grown for one of the sugar factories in the Arkansas Valley were attacked. The serious nature of this outbreak was not realized until too late, and although strenuous efforts were finally made to control the "worms," the loss resulting from this infestation was estimated at 20,000 tons of beets, which would have been worth approximately $100,000 to the growers. Such severe losses are rather exceptional, although nearly every year the loss occasioned by webworms is far in excess of the amount imagined by the average beet grower.

To the progressive farmers in the Arkansas Valley the sugar-beet webworm is generally too well known to require a detailed description, although a few notes regarding the life history when infesting sugar beets may be of value.

GENERAL APPEARANCE OF THE SUGAR-BEET WEBWORM AND NATURE OF ATTACK.

The parent of this webworm (fig. 9) belongs to the lepidopterous family Pyralidæ, and is a tawny-brown, active moth, or "miller," with a wing expanse of about 1 inch.

It is larger and more conspicuously colored than the garden webworm which is shown in figure 10.

FIG. 9.—The sugar-beet webworm (*Loxostege sticticalis*): Moth. Twice natural size. (Reengraved after Insect Life.)

The moths deposit their pearly-white eggs singly or in rows of from two to five or more, usually on the under side of the leaf. When deposited in rows they overlap more or less. Each female moth is capable, under normal conditions, of depositing at least 200 eggs. From these eggs hatch the small larvæ, or "worms." When first hatched the "worms" are whitish, with black heads, but as they feed and increase in size they become green, with dark markings. The very young larvæ eat small holes in the under side of the leaves without, however, cutting through the upper epidermis, but as they increase in size they consume almost the entire leaf, with the exception of the larger veins and the petioles. The "worms" prefer the older leaves, and unless the food supply is nearly exhausted do not eat the young leaves at the center of the plant. When full grown the "worms," which are slender and about an inch in length, leave the beets and burrow in the soil, usually close about the infested plants, and spin tubelike cases in which they later pupate. The pupæ are slender, yellow-brown, inactive objects, from which during the summer months the moths issue within a few days. The moths, after issuing, feed on the nectar in alfalfa or other blossoms and within a few days mate and are ready to commence depositing eggs for another generation or brood of "worms."

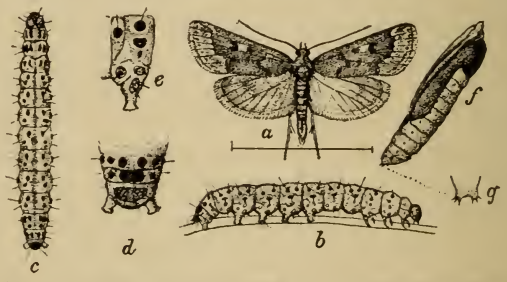

FIG. 10.—The garden webworm (*Loxostege similalis*); *a*, Male moth; *b*, larva, lateral view; *c*, larva, dorsal view; *d*, anal segment; *e*, abdominal segment, lateral view; *f*, pupa; *g*, cremaster. *a*, *b*, *c*, *f*, somewhat enlarged; *d*, *e*, *g*, more enlarged. (After Riley, except *c*, from Chittenden.)

LIFE HISTORY AND HABITS.

In rearing experiments conducted at Rocky Ford, Colo., the average time required from the deposition of the eggs until the moths issued was a little more than a month. The egg stage was observed to vary from 3 to 5 days, the larva stage from 17 to 20 days, and the pupa stage was usually 11 days. These variations were from records of successive generations.

So far as the writer has been able to determine, there are three generations or "crops" of webworms in the Arkansas Valley each year. There may be a fourth generation, but if so it is not clearly marked and possibly occurs early in the season on weeds such as Russian thistle (*Salsola tragus*) and lamb's-quarters (*Chenopodium album*). For the sake of convenience we may assume that only three generations occur yearly. The periods during which the writer observed the webworms of these successive generations in evidence on sugar beets in the Arkansas Valley ranged from about the middle of June until early July for the first generation and from about the middle of July until well into August for the second generation, while the third brood occurred in September.

In reality the generations are not sharply marked and considerable overlapping may occur. In general the danger period extends from shortly before the middle of June until well into September. The first generation of webworms may be expected at its height of destructiveness during the latter half of June, at a time when the beets are comparatively small and least able to resist the attack. (See fig. 14.) At this season the infested beets may actually be killed by this webworm, which, after eating all the leaves, may destroy the crown of the plant. Whenever the crown is destroyed the beet dies. So far as the writer has observed, the acreage destroyed in this way is very small and ordinarily occurs only when the infested beets are young and the available leaf surface limited. By the time the "worms" of the later generation are present the beets have become of good size and, although they may be completely stripped of all but the youngest leaves, it is rarely that any are killed. (See figs. 11, 12.)

The larvæ of the first generation, after maturing and burrowing into the ground, pupate promptly and the moths issue within a few days and deposit eggs for the second generation. The "worms" of this next generation, on reaching maturity, likewise burrow into the ground and spin their tubelike cases. However, only about half of them pupate promptly, the others remaining unchanged in the tubes until the spring of the following year. From the pupæ which develop in August, moths issue which deposit eggs for the third or September generation, and these "worms" remain unchanged throughout the

winter. It will thus be seen that about half the webworms of the second generation and all of those of the third generation, which have not been destroyed by parasites or through artificial or natural agencies, live through the winter in their tubes in the soil. These "worms" pupate late in the spring and the moths which issue deposit eggs for the first generation.

The moths when depositing eggs are often to be found in the beet fields in enormous numbers, and when disturbed may be seen flying close above the beet leaves in "clouds." When such numbers of moths are observed in a beet field they should serve as a warning to the

FIG. 11.—A medium sized sugar-beet plant defoliated by the sugar-beet webworm in July. (Original.)

grower that a "crop" of webworms may be expected within the next week or 10 days.

As a rule the first and second generations are the most destructive, the third generation, which is actually only a partial one, rarely causing serious damage. It seldom happens that the "worms" of successive generations infest the same patch of beets to a serious extent. Thus a certain field may be infested by the webworms of the first generation, while the moths which develop from them may drift to adjoining fields to deposit eggs for the next generation.

The webworms often appear very suddenly and apparently without warning in certain fields, and it is not uncommon for the growers to express the idea that they have migrated from adjoining fields.

This, however, is not the case, but their apparently sudden appearance is explained by the fact that the young webworms are easily overlooked and that during the last few days before they reach maturity their growth is very rapid. It frequently happens that from 50 to 300 eggs are deposited on single beet plants, and in extreme cases as many as 500 eggs may be so placed. The worms hatching from these eggs remain upon the beet on which they hatched until they reach maturity, unless all the leaves are destroyed and they are thus forced to crawl to another beet to obtain food.

FIG. 12.—Sugar beets defoliated by the sugar-beet webworm in July. (Original.)

CHARACTER OF INJURY.

It is impossible to state definitely the damage to sugar beets that an infestation of webworms may cause, as this may vary from almost no perceptible loss to the complete destruction of the infested plants, the extent of the injury depending on the number of webworms present, the size of the infested beets, and various other factors, such as climatic conditions, soil fertility, and water supply. As previously mentioned, small beets may be killed outright (see fig. 14), while larger beets may be completely stripped of foliage. With large beets new leaves will usually be put out promptly and their apparent recovery will take place quickly, especially if they are irrigated as soon as possible after the defoliation. Although new leaves are soon put out, defoliation retards the growth of the beet roots. (See fig. 13.) The writer has seen beet roots which at the time the tops were defoliated, in early July, were more than an inch in greatest diameter that made absolutely no gain in weight or size for three weeks after the leaves were destroyed. It might be added that these beets were in good, fertile soil and were watered

even while the webworms were destroying the foliage. Judging from personal observations and from the statements of many growers, the writer may state that when sugar beets have been defoliated by webworms during the growing season a loss of from 1 to 5 tons of roots to the acre may be apparent at harvest time. The decrease in tonnage is not the only damage, as analyses of such beets have indicated losses of both sugar content and purity, which in some cases have reduced the price $1 a ton. Another injurious feature which follows defoliation is that the soil about the beets is exposed to the direct rays of the sun, allowing the moisture to evaporate rapidly, and if the supply of irrigation water is limited this may become a serious matter.

FIG. 13.—Large sugar-beet plants, showing defoliation and weakened roots due to attack by the sugar-beet webworm in August. (Original.)

It will be seen that the sugar-beet webworm is a pest capable of causing extensive damage and that measures tending toward its control are worthy of careful consideration.

NATURAL ENEMIES.

Fortunately this species has natural enemies, among the most efficient of which are blackbirds. These birds often gather in enormous flocks in the infested beet fields and feed on the webworms. Unfortunately the webworms are not thus attacked until they have become nearly full grown and attain a size that renders them more conspicuous. As a result, it generally happens that the infested beets are partially or completely defoliated before the birds have completed their good work. The destruction of the "worms," however, lessens the possible number of the succeeding generation. The webworms are also reduced in number by true parasites, and in some cases the writer has found fully 50 per cent of the overwintered larvæ killed in this way. One of the most common parasites is a little wasplike insect known scientifically as *Diosphyrus vulgaris* Cress., a braconid.

OTHER CHECKS.

As previously noted, the webworms burrow into the soil about the infested plants, and when the beets are plowed out at harvest time many of the worms are crushed or are so deeply buried that the moths, if they succeed in developing, are unable to leave the tubes, and consequently perish. In spite of these checks there will be every year some areas of greater or less extent where the webworms will occur in injurious numbers and where spraying or other artificial control measures will be necessary.

FIG. 14.—Field of young sugar beets destroyed by the sugar-beet webworm in late June. (Original.)

EXPERIMENTS WITH REMEDIES.

During the time the writer has been stationed in the Arkansas Valley he has given special attention to means of controlling this webworm, and in his opinion spraying with Paris green has proven by far the most effective and satisfactory remedy. The writer has made many experimental tests with a variety of insecticides and has also supervised a considerable amount of practical work against this species, as a result of which study he considers the following formulas as most efficient:

Formula No. 1.

Paris green	pounds	3
Whale-oil soap	do	6
Water	gallons	100

Formula No. 2.

Paris green	pounds	3
Lime	do	3
Water	gallons	100

These mixtures have been applied to sugar beets with various types of sprayers (figs. 15–22) at the rate of from 80 to 125 gallons per acre, and the results have been uniformly successful in controlling the webworms. As a rule, 100 gallons per acre should be applied and the spraying commenced as soon as possible after the webworms have hatched. Where possible the spray should be applied at about 80 pounds pressure, although the writer has observed good results where only 40 to 50 pounds pressure was maintained. The leaves of sugar beets are quite smooth, and in order to apply an even coat of poison it is necessary to add some adhesive to the spray mixture. In the writer's experience nothing has proven more satisfactory for this

FIG. 15.—Barrel sprayer suitable for use against the sugar-beet webworm. (Original.)

purpose than whale-oil soap. If it is not obtainable, ordinary laundry soap may be used with about equally beneficial results, although it is more expensive. Lime, as recommended in formula No. 2, serves to an extent as an adhesive and has the additional effect of neutralizing any free arsenic which may be present in the Paris green. Lime, however, renders the mixture somewhat caustic, and this formula is less pleasant to use than is one in which soap is used as the adhesive agent.

Refuse molasses from the beet-sugar factories was given extensive tests as a substitute for soap, and when used at the rate of from 3 to 6 gallons in 100 gallons of mixture it served as an effective adhesive. The molasses, however, contains a considerable amount of

alkali and other impurities which tend to make soluble some of the arsenic and copper in the Paris green. The soluble arsenic burns the beet foliage, and on account of this injury refuse molasses is not recommended. It may be interesting to add that in experiments which the writer made with Paris green against other species of insects, using as an adhesive refuse molasses from cane mills, which was less highly charged with impurities, the results were satisfactory, and no burning of the sprayed foliage occurred.

Several standard brands of arsenate of lead have been tested against the sugar-beet webworm in the Arkansas Valley, and with-

FIG. 16.—Barrel sprayer in action against the sugar-beet webworm. (Original.)

out exception the results have proven unsatisfactory. The arsenate was used at the rate of 6, 8, and 10 pounds in 100 gallons of water, and 100 gallons per acre applied, but the webworm was not controlled. In these experiments a large traction sprayer and an ordinary barrel sprayer were used.

Zinc arsenite, when used at the rate of 4 pounds in 100 gallons of water and applied at the rate of 125 gallons per acre, was effective. It was, however, noticeably slower in its killing effects than Paris green as recommended in formulas Nos. 1 and 2, and when used at this strength was equally as expensive as an effective application of Paris green.

Paris green will kill the sugar-beet webworm when used at the rate of 2 pounds in 100 gallons of water, but its action is comparatively slow. It can also be safely used on sugar beets at the rate of 4 pounds in 100 gallons of water, although this amount is excessive and unnecessarily expensive. All things considered, either formula No. 1 or formula No. 2 can be depended on for the most satisfactory results.

Many beet growers demand that an insecticide to be used against webworms shall be immediately effective. It is of course unreasonable to expect immediately fatal results from a stomach poison. When Paris green is properly applied against this webworm at the rate of 3 pounds in 100 gallons of water, a fairly large number of dead webworms will be found about the sprayed beets at the end of 24 hours, and at the end of three days practically all webworms should be dead.

Dusting with Paris green and lime has also proven effective against this webworm when used at the rate of from 2 to 4 pounds of the poison in 100 pounds of air-slaked lime. The "dust" may be applied by shaking it from a coarse sack or with a "powder gun." This method is slow, would increase the cost of application more than 50 per cent, and is difficult to apply in an even coating.

Occasionally a field of beets may have been irrigated just before an infestation of webworms becomes apparent, and in such a case the soil is likely to be so wet that the prompt use of a sprayer will prove impracticable and dusting may then be employed to advantage.

SPRAYING MACHINERY.

For spraying large areas of sugar beets a geared traction sprayer of 125 gallons' capacity (figs. 20–22) will prove profitable; but for the average grower, whose planting does not exceed 20 acres, this type of machine is too expensive and unnecessarily large, and a smaller, much cheaper sprayer, which can be assembled at home, will give satisfactory results. Such a sprayer may be fitted up by mounting a spray pump in a 50-gallon barrel on an ordinary one-horse, two-row beet cultivator, from which the "handles" and "shoes" have been removed. This arrangement will be readily understood by referring to the accompanying illustrations (figs. 15, 16). The four-row attachment is connected with the pump by a rubber hose and is fastened to sections of plank which are bolted to the cultivator frame and extend out behind the wheels. The row attachment is made of $\frac{3}{8}$-inch and $\frac{1}{4}$-inch iron pipes and can be put together by a plumber. Three types of row attachments are illustrated. Number 1 (fig. 17) is the simplest and will give satisfaction under ordinary conditions. This may be built to cover eight rows of beets instead of four. The eight-row attachment, however, is rather cumbersome

and may cause some trouble by catching in fences, etc., when turning at the end of the field. Number 2 (fig. 18) is so arranged that two nozzles are above each row of beets. This is desirable, but not

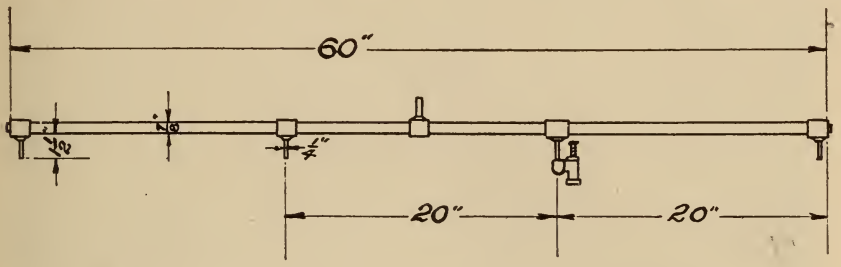

FIG. 17.—Four-row attachment for beet sprayer. (Original.)

absolutely necessary, when large beets are to be sprayed. Number 3 (fig. 19) is so made that both the surface and the underside of the beet leaves are reached by the spray. By using this attachment

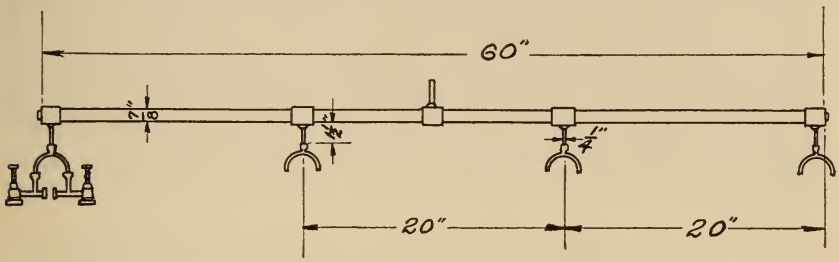

FIG. 18.—Four-row attachment for beet sprayer. (Original.)

beets can be very thoroughly sprayed and young webworms on the underside of the leaves will be more quickly killed than when only the surface of the foliage is wet by the spray. A nozzle arrange-

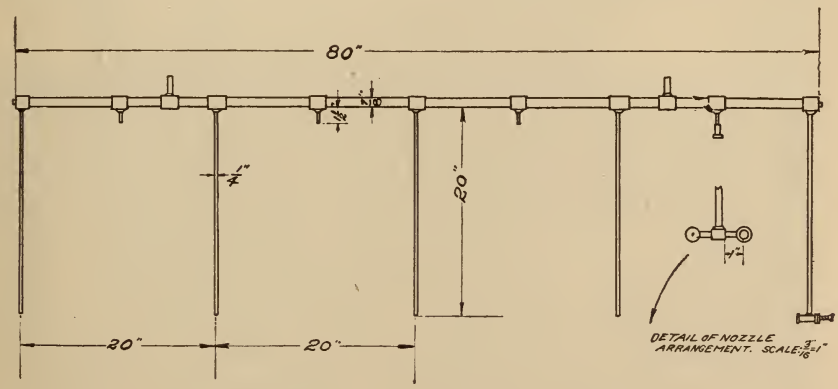

FIG. 19.—Four-row attachment for beet sprayer: Nozzles arranged so that both the upper and lower sides of the leaves may be wet by the spray. (Original.)

ment such as is obtained with this type is necessary when Bordeaux mixture is applied for the leaf-spot disease (*Cercospora beticola* Sacc.).

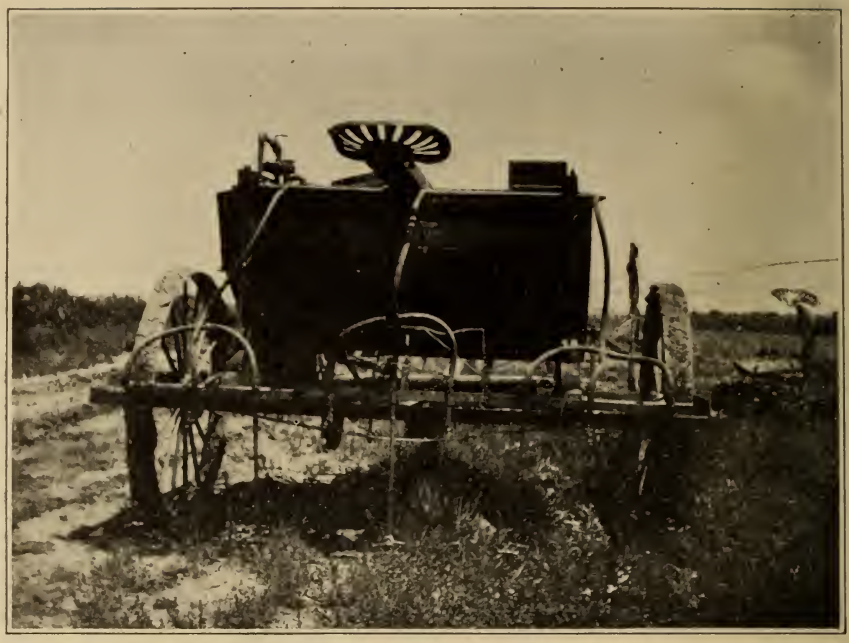

FIG. 20.—Geared traction sprayer suitable for use against the sugar-beet webworm. (Author's illustration.)

FIG. 21.—Geared traction sprayer in action against the sugar-beet webworm. (Author's illustration.)

In fitting up a sprayer a strong, heavily built pump provided with an agitator should be used, and the necessity of using first-class nozzles is imperative. The nozzles should be of the Vermorel type

FIG. 22.—Filling a traction sprayer for spraying against the sugar-beet webworm. (Original.)

(fig. 23), which delivers a fine, mistlike spray. This type of nozzle, together with the pump, hose, and other fittings, can be purchased from any reliable dealer, and the entire sprayer can be fitted up at an expense not exceeding $25.

With this sprayer and a horse it is easily possible for one man to spray 5 acres of sugar beets a day. With a large traction sprayer a much greater acreage may be treated in the same length of time.

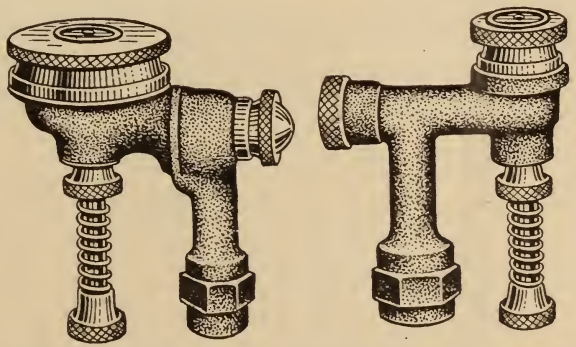

FIG. 23.—Type of Vermorel nozzles suitable for spraying sugar beets against the sugar-beet webworm.

COST OF SPRAYING.

The cost of labor, materials, etc., for spraying sugar beets will vary under ordinary circumstances from $1 to $2 an acre. The price received for sugar beets by the growers in the Arkansas Valley

usually exceeds $5 a ton. As previously mentioned, a defoliation by the sugar-beet webworm may reduce the yield of sugar beets 1 to 5 tons to the acre and also cause a loss in sugar content and purity. As this damage can be absolutely prevented at a cost not exceeding $2 an acre, the profits from spraying infested beets are apparent.

CONCLUSION.

An easily accessible supply of water will aid materially in keeping down the cost of spraying. Water from the irrigation laterals may be used, but in all cases it should be carefully strained to prevent dirt and other material from getting into the pump and clogging the nozzles. Water that is highly charged with alkali should be avoided.

After a sprayer is used it should be carefully washed with clean water and all the working parts thoroughly oiled. It is a mistake to allow a sprayer to stand in the field exposed to sun and weather, and it will pay to keep it housed when not in actual use.

As a final word, it may be well to state that webworms, and with few exceptions most other insects which affect sugar beets in the Arkansas Valley, can be easily and cheaply controlled. When this fact is more generally accepted by the beet growers it is safe to say that sugar beets will produce still better profits.

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